Name: ____ AP Biology
[redacted]

Chapter 8 Active Reading Guide
Photosynthesis

This chapter is as challenging as the one you just finished on cellular respiration. However, conceptually it will be a little easier because the concepts learned in Chapter 7 – namely, chemiosmosis and an electron transport system – will play a central role in photosynthesis.

1. As a review, define the terms *autotroph* and *heterotroph*. Keep in mind that plants have mitochondria and chloroplasts and do both cellular respiration and photosynthesis!

Section 1

2. Take a moment to place the chloroplast in the leaf by working through Figure 7.3. Draw a picture of the chloroplast and label the *stroma, thylakoid, thylakoid space, inner membrane*, and *outer membrane*.

3. Use both chemical symbols and words to write out the formula for photosynthesis (use the one that indicates only the net consumption of water). Notice that the formula is the opposite of cellular respiration. You should know both formulas from memory.

4. Using ^{18}O as the basis of your discussion, explain how we know that the oxygen released in photosynthesis comes from water.

5. Photosynthesis is not a single process, but two processes, each with multiple steps.
   a. Explain what occurs in the *light reactions* stage of photosynthesis. Be sure to use *NADP*$^+$ and *photophosphorylation* in your discussion.

   b. Explain the *Calvin cycle*, utilizing the term *carbon fixation* in your discussion.

6. The details of photosynthesis will be easier to organize if you can visualize the overall process. Using Figure 8.5 identify the items that are cycled between the light reactions and the Calvin cycle.

Section 2

This is a long and challenging concept. Take your time, work through the questions, and realize that this is the key concept for photosynthesis.

7. Some of the types of energy in the electromagnetic spectrum will be familiar, such as X-rays, microwaves, and radio waves. The most important part of the spectrum in photosynthesis is visible light. What are the colors of the *visible spectrum*?

8. Notice the colors and corresponding wavelengths. Explain the relationship between wavelength and energy.

9. Study Figure 8.9 carefully; then explain the correlation between an *absorption spectrum* and an *action spectrum.*

10. Describe how Englemann was able to form an action spectrum long before the invention of a spectrophotometer.

11. A *photosystem* is composed of a protein complex called a ____________________ complex surrounded by several ____________________ complexes.

12. Within the photosystems, the critical conversion of solar energy to chemical energy occurs. This process is the essence of being a producer! Using Figure 8.12 as a guide, explain the role of the components of the photosystem listed below.
    a. Reaction center complex:

    b. Light-harvesting complex:

    c. Primary electron acceptor:

13. *Photosystem I (PS I*) has at its reaction center a special pair of chlorophyll *a* molecules called P680. What is the explanation for this name?

14. What is the name of the chlorophyll *a* at the reaction center of PS I called? _______

15. *Linear electron flow* is, fortunately, easier to understand than it looks. It is an electron transport chain, somewhat like the one we worked through in cellular respiration. While reading the section "Linear Electron Flow" and studying Figure 8.13 in your text, **briefly** summarize each step.

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16. The following set of questions deals with linear electron flow:

a. What is the source of energy that excites the electron in photosystem II? _____

b. What compound is the source of electrons for linear electron flow? __________

c. What is the source of O_2 in the atmosphere? ___________________________

d. As electrons fall from photosystem II to photosystem I, the cytochrome complex uses the energy to pump _______________ ions. This builds a proton gradient that is used in chemiosmosis to produce what molecule? _______________

e. In _______________, $NADP^+$ reductase catalyzes the transfer of the excited electron and H^+ to $NADP_+$ to form NADPH.

**Notice that two high-energy compounds have been produced by the light reactions: ATP and NADPH. Both of these compounds will be used in the Calvin cycle*.

17. The last idea in this challenging concept is how chemiosmosis works in photosynthesis. Describe four ways that chemiosmosis is *similar* in photosynthesis and cellular respiration.

1.

2.

3.

4.

18. Use two key differences to explain how chemiosmosis is *different* in photosynthesis and cellular respiration.

19. List the three places in the light reactions where a proton-motive force is generated by increasing the concentration of H^+ in the stroma.
    1.

    2.

    3.

20. To summarize, note that the light reactions store chemical energy in ________ and ________, which shuttle the energy to the carbohydrate-producing ________ cycle.

Section 3

The Calvin cycle is a metabolic pathway in which each step is governed by an enzyme, much like the citric acid cycle in cellular respiration. However, keep in mind that the Calvin cycle uses energy (in the form of ATP and NADPH) and is therefore anabolic. In contrast, cellular respiration is catabolic and releases energy that is used to generate ATP and NADH.

21. The carbohydrate produced directly from the Calvin cycle is not glucose, but the three-carbon compound __________________________. Each turn of the Calvin cycle fixes one molecule of CO_2; therefore, it will take _____ turns of the Calvin cycle to net one G3P.

22. Explain the important events that occur in the *carbon fixation* stage of the Calvin cycle.

23. The enzyme responsible for carbon fixation in the Calvin cycle, and possibly the most abundant protein on Earth, is ____________________.

24. In phase two, the *reduction stage*, what molecule will donate electrons, and so is the source of the reducing power? __________

25. In this *reduction stage,* the low-energy acid 1,3-bisphosphoglycerate is reduced by electrons from NADPH to form the three-carbon sugar ___________.

26. Examine Figure 8.17 in your text while we tally carbons. This figure is designed to show the production of one net G3P. That means the Calvin cycle must be turned three times. Each turn will require a starting molecule of *ribulose bisphosphate (RuBP)*, a five-carbon compound. This means we start with _____ carbons distributed in three RuBPs. After fixing three molecules of CO_2 using the enzyme _______________, the Calvin cycle forms six G3Ps with a total of _______ carbons. At this point the net gain of carbons is _______, or one net G3P molecule.

27. Three turns of the Calvin cycle nets one G3P because the other five must be recycled to RuBP. Explain how the *regeneration of RuBP* is accomplished.

28. The net production of one G3P requires _______ molecules of ATP and _______ molecules of NADPH.

Section 4

29. Explain what is meant by a *C_3 plant*.

30. What happens when a plant undergoes *photorespiration*?

31. Explain how photorespiration can be a problem in agriculture.

32. Explain what is meant by a *C_4 plant*.

33. Explain the role of *PEP carboxylase* in C_4 plants, including key differences between it and *rubisco*.

34. Conceptually, it is important to know that the C_4 pathway does not replace the Calvin cycle but works as a CO_2 pump that prefaces the Calvin cycle. Explain how changes in leaf architecture help isolate rubisco in regions of the leaf that are high in CO_2 but low in O_2.

35. Explain the three key events in the C_4 pathway.
    1.

    2.

    3.

36. Compare and contrast C_4 plants with CAM plants. In your explanation, give two key similarities and two key differences.

37. Explain this statement: "Only the green cells of a plant are the autotroph while the rest of the plant is a heterotroph."